Contents lists available at SciVerse ScienceDirect

Chemical Engineering Research and Design

journal homepage: www.elsevier.com/locate/cherd

Residence time study of a two-phase mixture in a horizontal cylindrical vessel

Alistair S. Burrows[a], *Jong-Leng. Liow*[b,*], *Kevin Brady*[c]

[a] *Xstrata Technology, Level 4, 307 Queen Street, Brisbane, Queensland 4000, Australia*
[b] *School of Engineering and Information Technology, UNSW Canberra @ADFA, ACT 2600, Australia*
[c] *H 897 RSD Invermay, Victoria 3352, Australia*

ABSTRACT

A cold model of a rotary holding furnace was studied using water and a kerosene-LIX® 973N organic mixture which are immiscible. The flow of the feed was found to behave similar to a gravity current where the feed preferentially moved along the liquid–liquid interface. Visual observation and residence time distribution obtained showed that the flow of the lighter feed mixture was similar to a laminar flow but with a preferential route along the wall with the outlet spout. In the commercial-scale rotary holding furnace, plug flow conditions are considered desirable while mixing or short-circuiting is considered undesirable. The flow in the cold model was fitted to a plug flow and three CSTRs all in series and a particular depth of the upper layer of organic was found where mixing with the bath fluid was a maximum. Air bubbling in the centre of the cold model showed that at low air flow rates, the air curtain acted to limit mixing but as the air flow rates increased, the increased circulation caused by the air flow increased mixing and negated the air curtain effect.

Keywords: Rotary holding furnace; Residence time distribution; Reactor model; Two-phase flow; Cold modelling

1. Introduction

The use of cylindrical vessels placed horizontally as separation devices or reactors is fairly common in industry. In the petroleum and chemical industries, baffles are used to settle the incoming multiphase liquid mixture and provide a tortuous path to facilitate the separation of liquids or settling of suspended solids. Horizontally positioned cylindrical vessels are also found in the metallurgical industry; examples include the Peirce–Smith converter, anode furnace and the nickel pressure leach reactor. These vessels are operated in batch mode involving a series of complex operations including gas injection, feed additions and product removal. The rotary holding furnace (RHF) is a horizontal cylindrical vessel that is used to settle a two-phase liquid mixture of copper matte and slag. Copper matte is a single phase mixture of iron and copper sulphides and is immiscible with the slag. The matte and slag are produced during the smelting of copper sulphide ores in an ISASMELT™ furnace (Errington et al., 1997); a modern copper smelting process designed and supplied by Xstrata Technology. Examples of the RHF vessel exist at Xstrata's Mount Isa copper smelter. The RHF acts as the interface between the continuous ISASMELT™ process and the batch Peirce Smith converters. It is used as a buffer for holding matte prior to its transfer to the converting step as well as for the gravitational separation of the matte from the slag. The matte–slag mixture is fed in at one end and exits through side ports close to the opposite end of the RHF (Fig. 1). Rollers on the base of the RHF enable it to tilt about its horizontal axis to allow the copper matte and slag to be poured out through separate side exit ports. The high temperatures and corrosive nature of the fluids do not allow submerged injection of the feed at the interface of the two fluids as is commonly found in mixer-settler equipment. Instead, the mixture is poured into the RHF through a launder onto the surface of the molten slag and allowed to separate by gravity. Internal aids, such as baffles, are not used as they do not survive the harsh environment. The RHF contents are tapped at convenient intervals depending on the downstream processes. Matte, the heavier liquid, is often entrained in the slag layer and results in the loss of copper when the slag is discarded. The copper can be recovered from the slag through a secondary process of crush-

* *Corresponding author*. Tel.: +61 3 62688009; fax: +61 3 62688999.
E-mail addresses: aburrows@xstratatech.com (A.S. Burrows), j.liow@adfa.edu.au (J.-L. Liow).
Received 13 December 2011; Received in revised form 24 May 2012; Accepted 3 June 2012
0263-8762/$ – see front matter © 2012 The Institution of Chemical Engineers. Published by Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cherd.2012.06.008